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April 1973

WORKING CAPITAL MANAGEMENT: A SYSTEMS DYNAMIC APPROACH

Working Paper No. 73

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BACKGROUND

This paper is the initial output of a continuing study of the application of system dynamics to building a financial model of the firm. The relationships employed herein are hypothetical. At a subsequent stage, the authors hope to test the viability of the model in a real situation. Inquiries from financial managers regarding the applicability of these procedures to specific situations are welcome.

ABSTRACT

The simulation model which is developed in this paper attempts to reproduce observed working capital system behavior by structuring the relationship existing among the policy factors, system states, and system actions. It allows the manager to test the impact upon the working capital variables of changes in working capital policy, changes in the firm's nonworking capital operations, and changes in the economic environment. An illustration of model use is provided, but the application of these principles to a real situation is reserved for a future effort.

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I. INTRODUCTION

Working capital management is concerned with administering the type, amount and timing of the firm's current assets and current liabilities. An optimal working capital policy would require that the level of each short term asset and liability be adjusted until any further change would cause the value of the firm to fall. The ideal working capital model would not only assist the financial manager in attaining this optimal condition at present, but would also help him to simulate working capital policy in response to a dynamic environment so that appropriate policy changes could be determined.

The purpose of this research is to introduce a procedure for modeling an integrated approach to working capital policy which holds promise for resulting in the ideal model mentioned above. A stimulation model, patterned on the techniques of system dynamics,[1] has been developed. It attempts to reproduce observed working capital system behavior by structuring the relationships existing among the policy factors (e.g., collections, investment in marketable securities, bank borrowing) and

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[1]See "World Dynamics," Jay W. Forrester, Cambridge, Massachusetts, 1971.

system states (e.g., loans, cash, receivables). The model allows the manager to determine the time response of the working capital variables to various working capital policies, changes in the firm's non-working capital operations and changes in the economic environment. As presently constructed, the model permits a limited test for determining the optimal working capital condition.

II. SYSTEM DYNAMICS

A system is any grouping of components which act together to achieve an outcome. System dynamics is a computer based simulation technique which views the system of interest as a collection of information-action-policy loops of the type shown in Figure 1. Variables in the

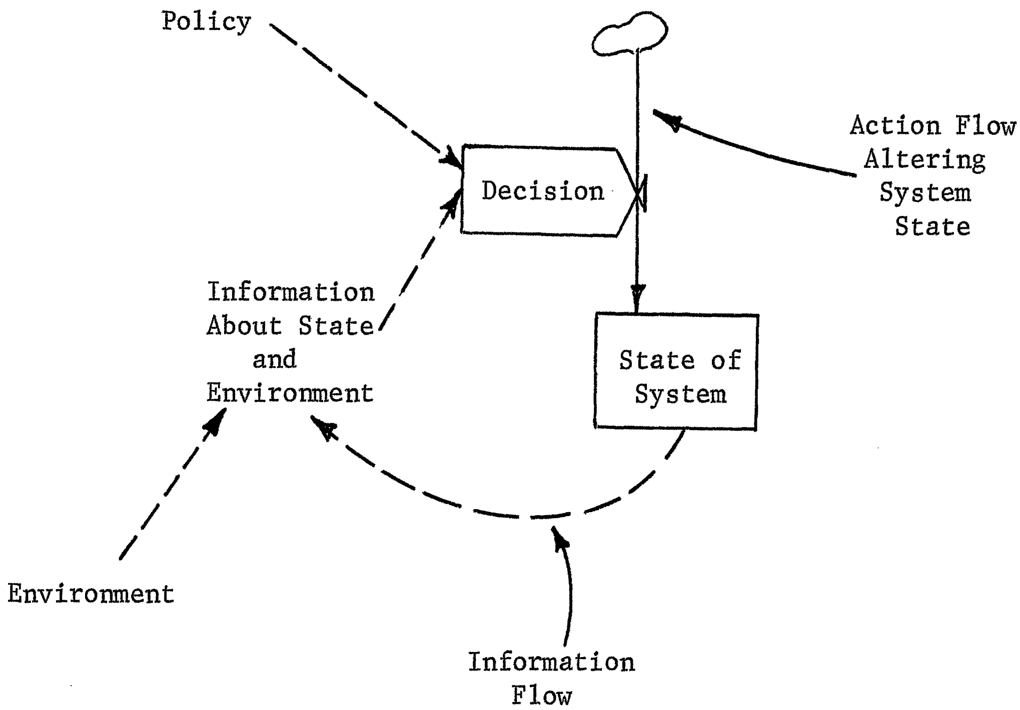


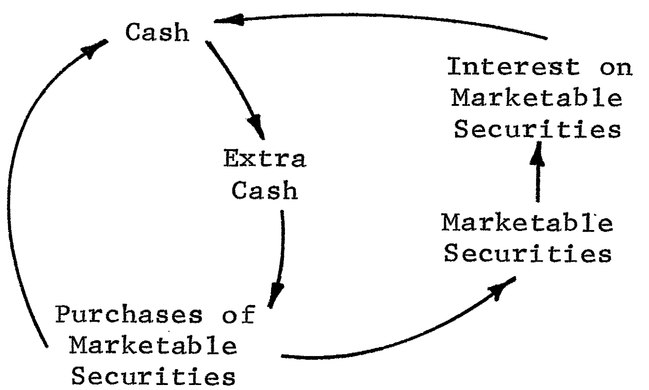
Figure 1 Feedback Loop

system which accumulate over time are known as levels of states. Factors which alter the state variables are flows or rates. Policy variables and other information factors affect the level-rate relationships.

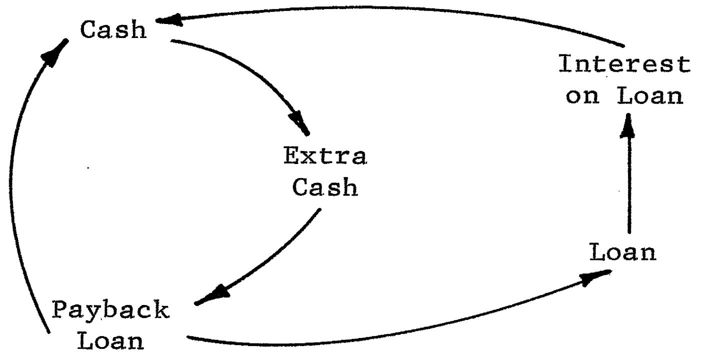
The initial step in the construction of a system dynamics model is to determine the causal relationships in the system of interest and to structure those relationships as a collection of interrelated feedback loops. In assembling the working capital model, it is useful to begin by identifying a relatively simple loop structure and to build from it to the complete complex model.

A basic element in working capital management is the maintenance of the firm's cash balance at a policy designated level. For simplicity, assume that deviations from this level caused by cash flows related to operations, financial flows, or extraordinary items, are dealt with by borrowing/repaying on a line of credit loan or by the purchase/sale of marketable securities. Figure 2 identifies the feedback loops which are part of this cash management process.

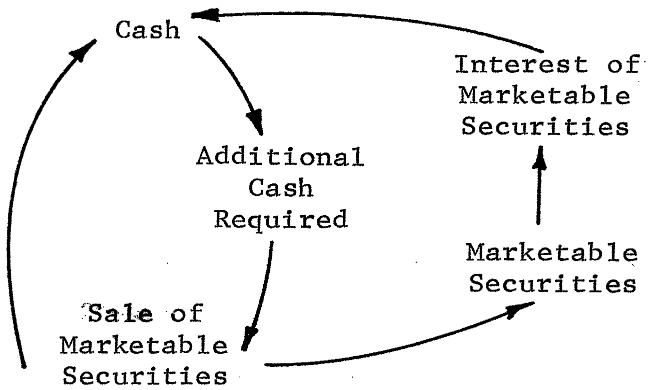
In Figure 2a, the recognition of an excess cash balance results in the purchase of marketable securities and a concomitant reduction in the cash balance toward the policy level. A feedback loop of this type, which seeks to control the state variable at a particular level, is called a negative feedback loop. A positive feedback loop, on the other hand, results in growth or decay of the state variable. In Figure 2a, for example, the recognition of excess cash results in a purchase of marketable securities and an increase in interest which leads to a further increase in the level of cash. The combined impact of these feedback loops upon the cash balance depends upon the comparative strength, or gain, in the



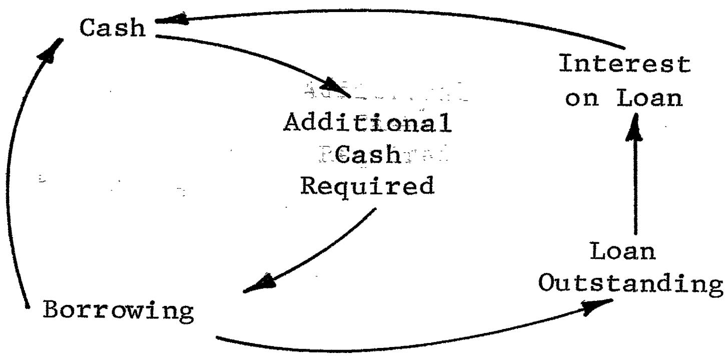
(a) Purchase of Marketable Securities With Excess Cash



(b) Repayment of Loan With Excess Cash



(c) Sale of Marketable Securities To Make Up Cash Deficiency



(d) Borrowing To Make Up Cash Deficiency

Fig. 2. Examples of simple feedback loops.

loops. In this case the negative loop dominates, but in the long run, the positive loop causes growth (perhaps undesired) in the cash balance.

Reduction of the cash balance by repaying loans on a line of credit is shown in Figure 2b. In the negative loop, cash is reduced by the action of paying back the loan. But repaying the loan reduces the amount of interest required to service this borrowing and thus increases the cash balance. Again the negative loop is stronger and the level of cash is controlled.

The control system which operates when the cash balance falls below the policy level is depicted in Figure 2c and 2d. The sale of marketable securities will result in an increased level of cash toward the policy level, but the interest lost will result in a decrease in cash. Likewise, borrowing on the line of credit increases cash, but the interest payment required to service the loan will cause the cash balance to fall. As in the cases of excess cash, the effects of the negative feedback loops dominate the (now) decaying effects of the positive feedback loops to control cash at the desired level.

The cash balance control system discussed in connection with Figure 2 can now be constructed and discussed as an integrated model of the feedback loops. Figure 3 describes the relationship which exists among three state variables (cash, loans, marketable securities), two rate variables (borrowing/repayment on line of credit, purchase/sale of marketable securities) and a number of related policy factors.

The rate of sales and the average use of the line of credit are assumed to specify a policy level of cash. Differences between the actual and policy cash levels lead to a recognition of extra cash or the need to obtain cash. The relative employment of marketable securities and bank

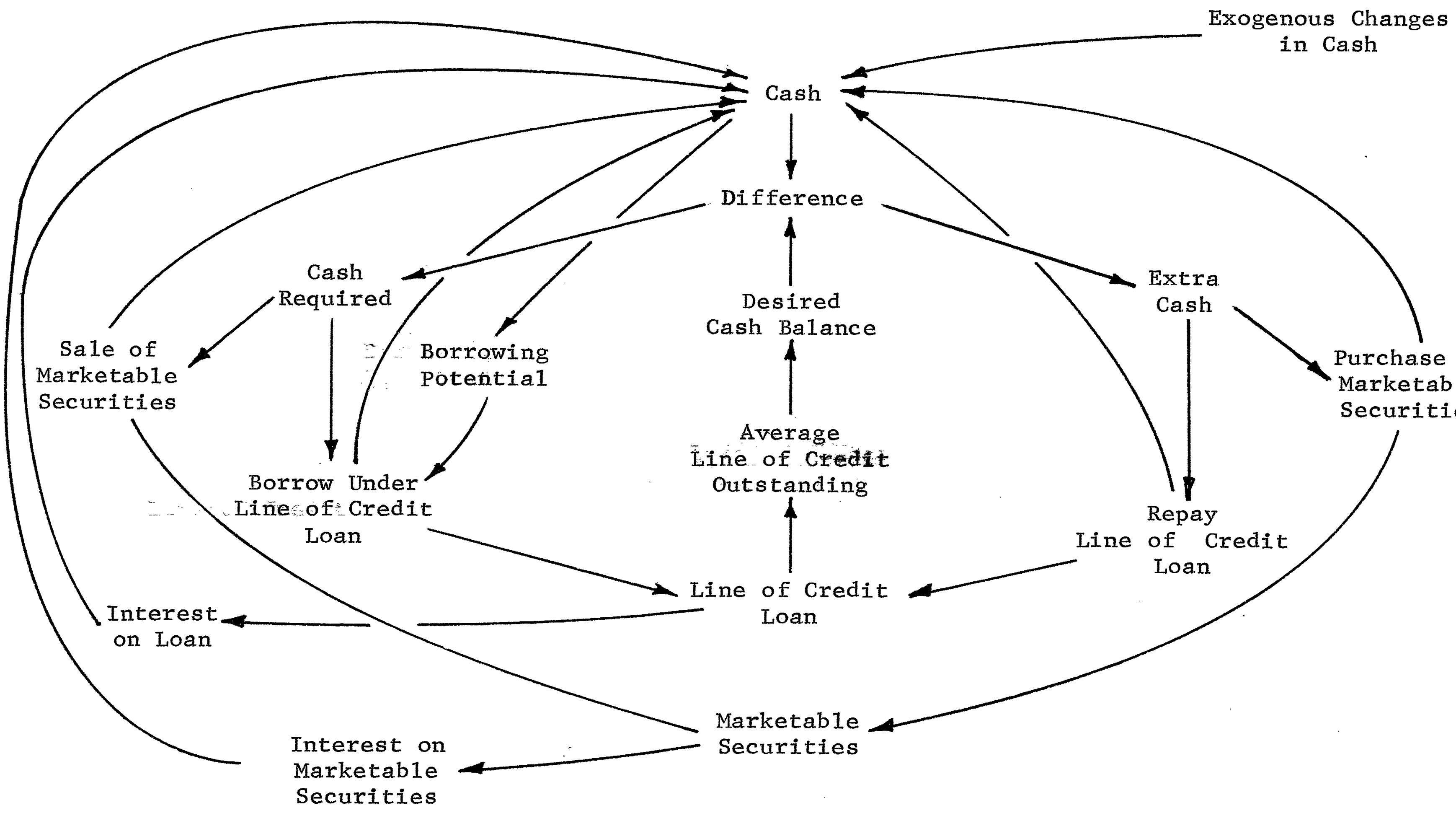


Fig. 3. A working capital feedback system.

loans in the cash control process is tied to the desired mix of short and long term investment and financing. It is important to note that the attempt to build an integrated model of part of the working capital sector has led to consideration of the income statement, the rest of the working capital variables and the long term assets and liabilities.

III. THE WORKING CAPITAL MODEL

The diagrammatic representation of the working capital model (Figure 4) identifies the important factors and suggests the direction of the causal relationships which describe how activities occur within a given time period.[2] The model includes both information and dollar flows internal and external to the working capital sector. In this work, only the most basic relationships to non-working capital factors are considered.

Simulation models of the type used here have an evolutionary structure which creates a time series of system states. In effect, the output of the stimulation is a time series of balance sheet variables which allows the decision maker to evaluate the impact of exogenous forces, policy changes, or resource availability constraints on the working capital position.

The mathematical construct of the model requires the specification of an initial system state and a quantitative description of the relationships which create the dynamic system behavior. As the simulation is run, the model calculates the impact of change upon each entity in the system

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[2]The system states are shown as rectangles, rates are depicted as valves and policies and information are represented in circles. Dollar flows are solid lines while information flows are dotted. Arrows denote the direction of influence of one factor upon another.

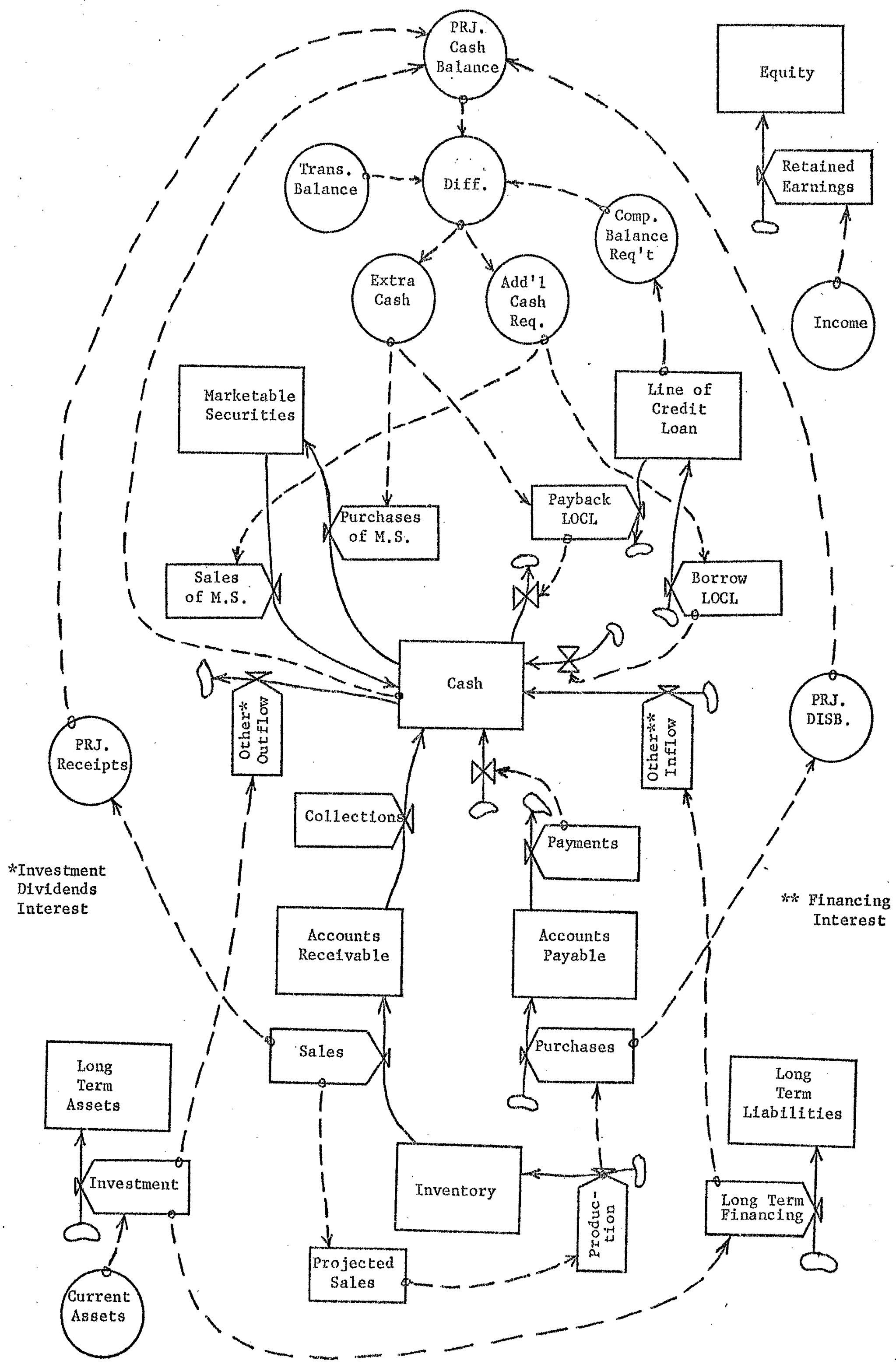

Figure 4 The Working Capital Model

to yield the state of the system at the end of the period. Calculation proceeds recursively to provide the complete time series of states as output.

The ability to specify relationships in the system is obviously an important factor in the construction of a successful model. The deterministic relationships specified by the income statement and balance sheet are easily specified. But the impact of policy changes upon a variable of interest may not be readily available. For instance, it is difficult to ascertain the effect on average collection period of an increase in expenditures on collections. Ultimately, such a relationship must be developed from an empirical study of the impacts of such a policy change, and/or from a manager's perception of the effects. Similar methods should be applied to the measurement of the whole host of working capital relationships. In this work, the authors have postulated the model's equations based on theory, experience and intuition. In a subsequent stage, an effort will be made to measure these functions from real data.

IV. A SAMPLE APPLICATION OF THE MODEL

A set of initial income statement and balance sheet conditions, working capital policies and working capital system relations including response lags and forecasting techniques for a sample firm have been postulated in the working capital model. Important policies include maintenance of a minimum cash balance determined as the maximum of a specified percentage of sales and a compensating balance requirement, a desired inventory to sales ratio and an average credit period which varies with sales. Response lags include delayed inventory and long term asset adjustments to a changing level of sales. Forecasts of sales, receipts and disbursements are based on smoothed past results. Although these conditions and policies do not come from a real business situation, they are considered to be representative.

For illustrative purposes, the pattern of sales shown in Figure 5 is assumed to prevail over a 36 month time horizon. The model calculates

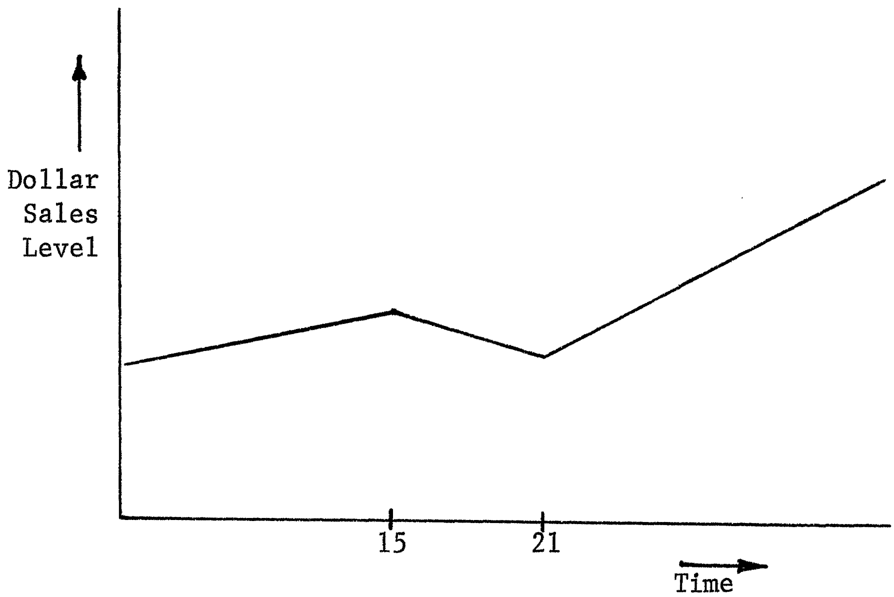

Figure 5 Pattern Of Sales

the single period impact of the initial sales growth to determine the levels of the working capital variables at the end of the first period. The process is repeated for each of the periods to produce the output exhibited in Figure 6.

Initially, the level of cash is set above the policy determined minimum cash balance. As a result, marketable securities are purchased with the extra cash during the first half of the initial growth period. But during the sales growth phase the required minimum balance increases faster than the ability of the firm to generate cash from operations (as a result of the need to maintain ever-higher inventory and receivables levels). Eventually, the initial excess cash is depleted, and the firm meets the need for cash by selling marketable securities (this need could also be met by borrowing, but the model assumes that the firm first depletes its marketable securities holdings).

In period 16, sales begin to decline. Inventory and receivables continue to grow due to lags in the system, and the need for cash becomes more acute. The sale of marketable securities continues until the firm's holdings are reduced to zero. Then, borrowing begins. Meanwhile, the need for cash is reduced by the drop in sales, and the peak need for funds passes during the sales decay.

Finally, sales begin to increase at a rate in excess of that enjoyed during the initial growth period. Inventory continues to decline and receivables increase slowly at the beginning of the growth spurt, and, as a result, cash increases rapidly. Excess cash results in loan repayment and the purchase of marketable securities. Then, inventory and receivables increase in response to the continuing growth in sales and the excess cash levels once again begin to decline.

How is this information of value to the financial manager? By simulating the effects of various forecasted sales patterns the manager can arrange appropriate sources and amounts of required financing. By using the model to simulate the impact of changing one or more working capital policies, the desirability of actually making such changes can be determined. Lastly, in the face of constraints on the availability of financing or inputs to the production process, the manager is forewarned to take actions to alleviate the problem.

SUMMARY

This paper is a progress report of an ongoing research project which attempts to apply the concepts of system dynamics to the firm's working capital management problem. A model has been constructed to aid in the analysis of the effect of exogenous forces, policy changes and resource constraints on working capital position. To this point, experience, intuition and theory have been used to construct working capital relationships and policies which approximate the real situation. As the work continues, an effort will be made to incorporate empirical data and the perception of financial managers. System dynamics shows great promise as an important tool for financial managers.

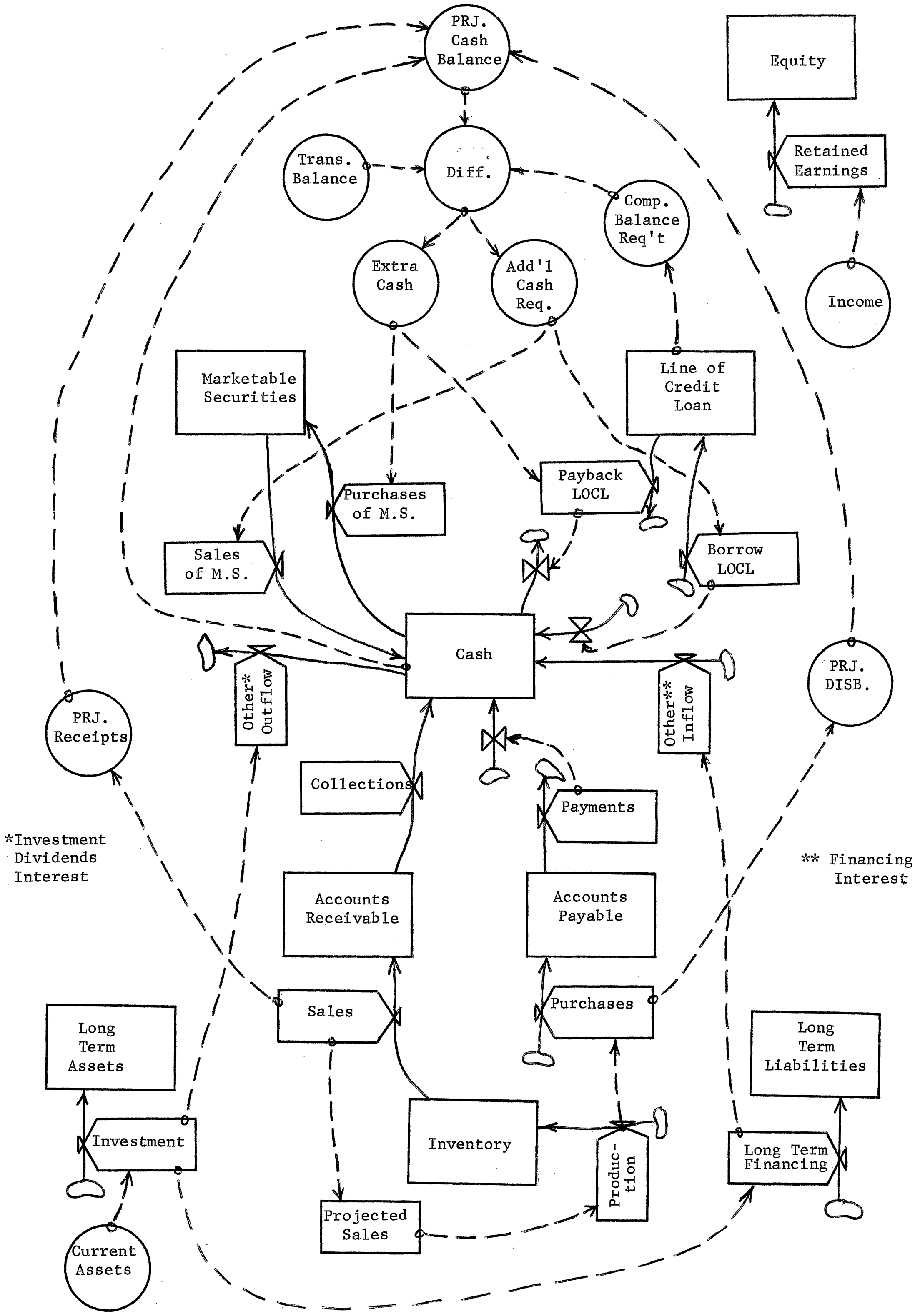

Figure 4 The Working Capital Model